AN INVESTIGATION OF THE EFFECTS OF SOFTENING AGENTS ON THE SPINNING OF RAMIE FIBER

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SUMMARY

In the United States commercial use of ramie fiber which is grown in the Everglades of Florida has been relatively limited due to difficulties encountered in yarn manufacture processing. The fiber, perhaps the strongest natural fiber known, has a number of desirable characteristics. Its great toughness, greater wet strength, high luster and good resistance to attack by micro-organisms has led to efforts over the years to enable economic use of the fiber in conventional yarn manufacturing processes.

Development of chemical agents which may readily be applied to fiber and which accomplish lubrication and softening was expected to minimize processing difficulties.

This investigation was undertaken as exploratory research to ascertain the influence of softening agents on ramie fiber in manufacturing processes. Manufacturing trials on each of 18 five-pound sample lots of fiber treated with different commercial softening agents were accomplished on long staple fiber processing equipment. Instrumental measure of fiber friction in card sliver form was investigated for correlation with observed spinning processing qualities in these manufacturing trials. Efforts were made to obtain a measure of the influence of these softening agents on another characteristic, the tendency exhibited by ramie fibers to compact under pressures encountered in yarn

manufacturing processes.

Each of 17 different softeners tested in manufacturing trials proved beneficial in manufacturing trials, particularly in picking and carding. Insufficient improvement in processing quality was occasioned by these softening treatments for determination of the significance of card sliver drag measurements. In overall appraisal, softening as evidenced by the 'hand' of the fiber, sliver drag measurements, and general processing quality in manufacturing trials, the cationic type of softening agent appeared to effect the greatest benefit.

Measurements of bulk fiber compression to ascertain any difference in the compacting tendency as influenced by softening treatments were inconclusive. Failure to obtain confirming test results caused discard of test data from Instron Tester compression studies.

The poor processing quality of all sample lots and non-uniformity occasioned by the limited quantity of fiber in picker processing of each lot of softened fiber limited the significance of instrumental product non-uniformity tests which were made to substantiate observations made in processing.

CHAPTER I

INTRODUCTION

Background.--Commercial use of ramie fiber has been limited, notwithstanding its recognition as perhaps the strongest natural fiber known. It is one of the oldest fibers known to civilization but its commercial usage has been limited by the fact that it cannot be economically spun into fine yarn counts and that harvesting and preparation of the fiber for textile usage entails costs which make the dry fibers more expensive than cotton, flax, or hemp. The fiber has a number of desirable characteristics, such as great toughness, greater wet strength, high luster, and good resistance to attach by microorganisms.

Ramie finds some use (1) in the manufacture of string and cordage, for industrial sewing threads, shoe laces, twines, rope, fishing net yarns, and in light sturdy fabrics including sheets, table linens, towels, tropical suitings, overalls, sail and tent cloth. Certain specialty uses are for some types of filter cloths, fire hose, packing for propeller shafts for ships, and more recently, in cigaret filters. The paper industry processes ramie fiber for use in bank notes. These relatively specialized uses fail to utilize the fiber production potential of growing areas in

the United States. The plant is extensively grown in the Everglades of Florida; however, the bulk of the fiber presently produced is exported rather than utilized in domestic production (2).

Manufacture of yarns and fabrics from ramie fiber has been made even more uneconomical because of the processing quality of the fiber. Specialized handling, not practicable in other than cottage-type industry methods, has been necessary. Successful production of ramie yarn and fabric has been accomplished apparently through the use of flax processing machinery (3). Attempts to process ramie fiber in staple form using conventional staple fiber processing machinery have been fraught with obstacles, viz., static electricity, characteristic inherent resistance of bundles of fiber to drafting, the brittle nature or low extensibility of the fiber, etc. These characteristics, which occasioned special handling, thus further increased the manufacturing cost and hindered its use for purposes for which it otherwise appeared highly suitable.

The developments in recent years of chemicals which impart lubricity to fibers, yarns and fabrics, or which may inhibit development of static charge in fiber processing suggest possible remedies to ramie processing ills. Chemical combinations which afford high lubricating properties along with high aqueous solubility provide increased possibilities of use due to ease of application, ease of removal and other

desirable properties. Numerous agents of this broad chemical family, generally classed as surface-active agents, or more commonly, as surfactants, are widely utilized to improve the 'hand' or feel to the touch of woven or knit goods made of popular natural fibers. Some usage is made of such agents to improve the drapability of fabrics. Some agents of this broad family of chemicals have been widely used as production aids in the processing of certain natural and synthetic fibers (4).

Lubrication of wool, rayon, and many synthetic fibers in either the staple or filament form, and inhibition of static electrical charge through the use of surfactants has been found beneficial. A wide variety of chemicals of this family of surfactants, known as softeners, has been developed which have a considerable range of chemical composition and, consequently, a wide range of properties. In anticipation of the probable beneficial effects of the use of such an agent or agents this study was undertaken to appraise the effect of a variety of such chemicals on the processing qualities of ramie fiber.

A search of the literature pertaining to ramie revealed little concrete information related to the use of softening agents on ramie fiber. Accordingly, this investigation was undertaken as a matter of exploratory research pertaining to a research project sponsored by the United States Department of Agriculture on the commercially feasible

aspects of processing ramie fiber.

The fiber (5) comes from the plant, Boehmeria nivea (L.), which is a member of the nettle family (Urticaceae). Unlike European nettles belonging to the genus Urtica, the species of the Boehmeria genus possess no stinging hairs. There are some 200 species, mostly tropical, though some are known to be grown in Asia and in North America north of the Tropic of Cancer. The species Boehmeria nivea, sometimes known as white ramie, and Boehmeria tenacissima, known as green ramie, comprise the principal specie grown for their fiber production. This classification as to white and green refers to the color of the underside of the leaves of the plant. Domestic production in the United States, principally in the Everglades of Florida, is largely of the white variety. Certain mutations, fostered for their greater yield or hardy growth characteristics in the area selected for their growth, have been developed. The plants grow best in moist, sandy, but well drained, soil and require considerable water, sunlight, and organic nitrogen.

The Everglades of Florida have been found to be well suited for the growth of ramie. Yields for a three-crop year have been reported of from 1800 to 2000 pounds per acre with an average soil yield in excess of 1200 pounds per acre (6). One large grower, Newport Industries, Inc., reported a yield of two million pounds of dry fiber on an area of 2000 acres in 1954. One tenth of this was degummed in the company's own

plant, the rest was exported to Japan, Switzerland, France, and Germany as raw fiber.

The fiber comes from the inner bark (bast) of the plant, which is covered by a non-cellulosic skin and which, in turn, covers the central, pith, portion of the bulk of the plant. This central portion makes up a substantial portion of the plant and is amorphous in character. In order to obtain the fiber for use, careful separation of these non-fibrous and non-cellulosic components from the fiber must be made. The separation of the pith and part of the non-cellulosic bark from the bast, a mechanical process known as decortication, is accomplished by several means. The oldest, but still practiced, involves hand processing, crushing by means of stones and sticks and then scraping with a knife. Economic considerations tending toward competitive fiber production have led to development of a variety of machines, one of which utilizes rotating beater blades which crush and beat the stalk and brush the fibrous portions to remove the non-fibrous matter. Some of this type of machine has been developed to effect this decortication in the field where the plant is harvested to thus eliminate the handling of the residue which has been found of value if left in the field to fertilize further growth of the plant for subsequent harvesting. A more effective procedure has been devised which utilizes the mechanical beater action of revolving blades augmented by a

spray of water which washes the crushed bark and pith from the fiber ribbons (7).

The decorticated fiber, in the form of ribbons containing many fibers held together by gums, waxes, and other intercellar material (8) then requires further separation to the individual fibers and cutting to staple length if the fiber is intended for staple fiber processing. The latter is accomplished by cutting the decorticated ribbons to the desired length. Separation to individual fibers, removal of the cementing gums, etc., is generally accomplished by chemical means. This must be accomplished with a minimum of damage to the fibers themselves. Numerous degumming processes are known and in general differ mainly in the techniques involved. In general, these consist of one or more treatments at the boil with caustic soda solutions, either in open vessels or under pressure, followed by rinsing and neutralization of residual alkali and, ultimately, drying (9).

These treatments to remove the cementing gums, when carried to completion, leave the fiber virtually free of waxes such as normally found in cotton, its closest chemical relative in the fiber family. Replacement of sufficient material for imparting necessary lubrication was thus an aspect to be investigated. Overlubrication was expected to cause a tendency to produce gummy deposits on rolls of processing equipment or adhesion between fibers and rolls of these machines as well as adhesion between fibers.

Investigation disclosed that ramie fiber for yarn manufacture is processed almost exclusively as a separated single fiber, not fiber bunches as occurs in flax processing to obtain linen. Viewed under a microscope, the fiber cells of ramie vary in cross section from hexagonal to oval and resemble cotton (10). In longitudinal view the difference is more marked. The single cells are of considerable length and width and show lengthwise dislocation marks with both longitudinal and transverse fissures. There is little evidence of the convoluted, collapsed cell structure characteristic of cotton fibers. It has been reported that ramie fiber has a higher degree of polymerization than most plant fibers (11). It is characterized by a high degree of crystallinity. The degummed fiber has been analyzed to be comprised largely of alpha cellulose. Its reported superior fiber strength has been attributed to its high crystallinity and its failure to provide expected yarn strength has been attributed to faults in continuity of the fibrils (12).

CHAPTER II

THE PROBLEM

Objective.--In this investigation, the immediate objective was to obtain a measure of the effect of certain chemical softeners as regards ramie staple fiber processing in yarn manufacture. To limit the scope of such an investigation it was considered necessary to select a method of instrumental analysis to permit ready comparison of selected softeners on certain recognized deleterious properties of the fiber. Comparison of differently softened lots of fiber in several yarn manufacturing processes and instrumental measure of certain fiber properties influenced by softening was expected to ultimately enable prediction of fiber performance in yarn manufacture.

Approach to the problem.--After a search of the published literature disclosed little concrete information in this regard, inquiry was made of some 24 manufacturers of textile chemicals for their recommendations and sample products. Their responses produced 87 samples of products for evaluation. Only three of the manufacturers reported previous experience with softening ramie fiber. All responses contained suggestions for softening based on the cellulosic nature of the fiber and the chemical nature of the agents suggested.

Accordingly, it was decided to first apply an equivalent concentration of each of the softening agents and effect a screening to select those softeners which imparted a 'hand' to ramie fiber most closely approximating that exhibited by cotton, a fiber of excellent spinning properties. Seydel (13) recommended the evaluation of softening of textiles by appraisal of 'hand', in view of the lack of a known laboratory method. Following this, further screening was to be accomplished by means of correlation of fiber processing properties as determined by observations supplemented by selected measures of certain physical properties which might be influenced by softening. Fiber friction was selected as one property for measurement. A related property, an observed tendency of the loose fibers to compact under applied pressure, called in this writing fiber compaction, was selected for investigation.

A literature survey on fiber friction compiled in 1954 by J. H. Langston and W. T. Rainey, Jr., (14) suggested numerous techniques for measurement of fiber friction. One of the earliest methods of measurement of fiber friction was devised by Adderley (15) wherein he measured the force required to cause a single fiber to slip when pressed between two pads of cotton fiber wrapped around glass slips. The single fiber was attached to a tube resting on the surface of water in a vessel and force was exerted by allowing the water to drain from the vessel. One of the pads holding the fiber

was attached to a lever system which enabled adjustment of the pressure caused to bear on the single fiber and on the other pad. Sen and Ahmad (16), in 1938, reported use of a technique similar to that used by Adderley but applied the pressure on the pads by means of a rubber diaphragm wherein a gauge of air pressure afforded a measure of the force on the single fiber. Nakval and Turner (17) used the Adderley apparatus but used ten fibers to minimize the influence of the wide variation they encountered with single fiber measurements. A technique reported by numerous investigators, Mercer (18), Gralen (19), Olofsson (20), Guthrie and Oliver (21), and Bartlett (22), was known as the stick-slip method. The basic principle used in this technique involved the mounting of a single fiber in a bow and causing it to bear with a gradually increasing, known force against a friction material such as horn or another fiber mounted on a leaf or clock spring or on a hydraulically mounted cylinder. A graphic record of the application of force and the alternate stick and slip action of the fiber thus gave a measure of fiber friction. Another technique was reported by Speakman and Stott (23) called the incline plane method wherein a number of fibers were arranged into a bow by stretching across a rectangular plate. The fibers were held away from the surface of the plate by a pair of thin cross members placed between the fibers and the plate at each end. The slide was placed on a small table covered with a pile cloth, then by

raising one end of the table the slide was eventually caused to slip. The angle at which slippage occurred enabled calculation of the coefficient of friction of the fibers.

Howell (24) in his comparison of the inclined plane and the stick-slip methods raised some questions as to the accuracy of either technique. Another method of some questionable accuracy was reported by Lipson (25) wherein he cemented hooks to either end of a single fiber and hung it over a friction material such as horn or rhinoceros hide and added weights to one hook until the fiber started to slide. This method was known as the capstan method. King (26) made modifications intended to improve the accuracy of this method.

A variation of this method was reported by Roder (27) in which he used a prepared cylinder of fibers over which a single fiber, at right angle alignment to the parallel fibers on the cylinder, was hung. Measurement of the force exerted by the single fiber against the cylinder of fibers as it rotated was accomplished by means of a torsion balance and a counterweight. When the rate of rotation was very slow the difference between counterweight and torsion balance load enabled calculation of the coefficient of static friction. Similar calculation made from load difference when the rate of rotation of the cylinder was more rapid gave a coefficient of kinetic friction. His method was specifically used to compare the effect of certain softening agents on rayon

staple fiber. His studies were extended and correlation made of fiber and yarn friction values and processing characteristics (28). His findings, which dealt with viscose rayon, a close relative to ramie, chemically speaking, indicated best softening as concerned staple fiber processing was obtained by the use of cationic surfactants. He concluded that the difference between static and kinetic friction coefficients might afford a good indication of processing characteristics.

The fiber twist method, which involved measurement of the force required to cause one fiber to slip within a like fiber entwined about it and held under tension, was used by Lindberg and Gralen (29). Their studies were made on wool fiber and included a measure of correlation with observed fiber-to-yarn processing characteristics. They also made tests on the breaking strength of wool top using an Instron testing machine for a high degree of correlation with fiber friction measurements by the fiber twist and by the stick-slip method. While no outright statement was made that Instron sliver (or top) breaking strengths afforded a measure of processing potential their inference was that Instron tests might be significant.

Mereness (30), in 1955, reported tests on 12 different varieties of cotton known to have different physical characteristics to ascertain the influence of interfiber friction and other characteristics on the strength of yarns spun therefrom. His technique was to perform breaking

strength tests on both hand and machine carded slivers on an inclined plane tensile testing machine. His studies included correlation of maximum stress before rupture of the sliver and also the work done in slowly pulling the sliver apart while an automatic recorder recorded the loading process. He went to some lengths to achieve a measure of statistical significance in the preparation of the slivers and in his correlation of the sliver drag and the skein strength measurements of different cotton fiber yarn product used for comparison. He reported poor correlation of results of fiber drag measurements with other fiber characteristics such as staple length, fineness, but good correlation with X-ray diffraction angle (relative degree of polymerization of cellulose chains) and fiber tensile strength (Pressley Index). Even though considerable effort was made to minimize experimental error, his correlation results caused him to conclude that "The interfiber friction results obtained in six (out of twelve) cotton samples gave no significant correlations with fiber drag results. Therefore it might be concluded that fiber 'form factors,' i.e., shape of cross section, crimp, etc., have more bearing on the determination of drag than does interfiber friction alone."

Hood (31) reported tests on fiber friction using a device he developed which embodied certain elements of the fiber-twist method. In his device two fibers were suspended

from alternating arms of the machine with the lower ends coupled to a device for inserting twist. The upper ends of the fibers were fastened to weights whose magnitude could be increased. For each weight tension placed on the fibers twist was inserted until slippage between the fibers was stopped. This number of turns of twist afforded an arbitrary measure for comparison of fiber friction of different fibers and surface treatments of fibers. His experiments involved a substantial number of tests with each tension weight and several different tension weights for each fiber or treatment analysis. He concluded, among other things, that the presence of fiber crimp increased friction, that colloidal silica increased the clinging power of cotton fibers, and that the shape of the frictional curve -- obtained by testing with his device -- may be correlated to the fiber's behavior during drafting. He reported tests on degummed ramie fiber which showed that ramie fiber has an irregular surface and a high friction coefficient. He stated that these results contradict the general belief that much of the difficulty in the processing of ramie staple fiber stemmed from a smooth, slippery nature of the fiber.

Wood (32) reported tests on measurement of the dynamic friction of viscose rayon fibers wherein he measured the force required to withdraw a single fiber from a bundle of similar fibers. He used a special device in which a

single fiber was coupled to a torsion wire and mirror arrangement for photographic recording of a trace of the force occasioned by the withdrawal of a fiber from a bundle of fibers held on a trolley whose motion away from the single fiber mount was accurately established. His report involved a considerable amount of statistics to establish the validity of his test results. The necessity for such measurements for predicting the processing character of viscose, according to the treatment accorded the fiber in manufacture, was affirmed.

The tensile properties of card and draw frame slivers were compared by Waggett (33) in measurements using an Extensometer. This device, a development of Cambridge University, embodies an electronic loading principle and is reportedly very accurate in measuring small tensile stresses. It is particularly adapted to production of a graphic record of these stresses. He compared a number of fiber finishes, surfactants, in their effect on the tensile properties of card and drawing sliver of both cotton and viscose. His emphasis in testing was to obtain an instrumental basis for predicting processing characteristics of fibers, particularly with regard to cohesion. For this purpose he defined cohesion as the ability of a web, sliver, or lap to hold together. According to his hypothesis, the primary factors in cohesion are longitudinal shape (kink), surface frictional properties, and flexural rigidity of the fibers. Plots of

load-elongation data on cotton slivers gave a relatively smooth curve but viscose sliver gave a stepped curve indicative of a stick-slip tendency. Greater orientation of fibers such as resulted from going from card to draw frame sliver gave a lesser width to the curve, that is, a lower extension until separation of the sliver. His explanation of this observation was that as the fibers were further parallelized less resistance to strain was afforded. A variety of techniques for application of softener, or finish, were reported. He reported steeping the fiber mass in an alcoholic solution of triethanolamine salts of different fatty acids followed by carding a small lot, approximating a handful, of the fiber at a uniform portion of the loading-stripping cycle of the card. The sliver thus obtained was tested on the Extensometer and the character and slope of the curve used for comparison of anticipated cohesion in processing. Also, for some of his tests, prepared card sliver was treated in a solution of the finish, then subjected to further trials such as drawing and roving manufacture. He reported correlation between processing characteristics, as pertains to cohesion in the web in carding and drawing, and the magnitude and slope of the Extensometer load-elongation diagrams. A low force in tensile testing was indicative of sagging card web or pobr cohesion in sliver or roving. A higher force was indicative of more satisfactory performance.

The frictional force in fringes of parallel fibers as measured by a device using a system of levers and springs with a known weight bearing on the fringes of fibers was described by Lord (34). He reported use of such a device for evaluating the effectiveness of different lubricants on fibers.

Special devices for measuring drafting forces were reported by Waters (35) and Grimshaw (36). These devices were similar in nature to a roll drafting arrangement with provision for measurement of the force encountered in drafting. This was accomplished by means of a cradle mounted pair of rolls to permit mechanical and/or electronic measurement of sliver drag. Waters reported development of such an instrument and its use in a study of the effect of three finishes on interfiber friction in textile fibers. His device, called the Draftometer, included an electronic recorder. From the graphic record he computed a smoothness ratio from the high and low values of a sample under test. This ratio was considered by him to be approximately equivalent to the ratio of static to kinetic friction between fibers. He reported that a higher non-uniformity ratio in the product was obtained where a higher smoothness ratio was found. He reported, without giving details, that good correlation was found between average drafting force, as measured by the Draftometer, and cohesion, as measured on an Instron testing machine.

For measurement of compression and compaction a limited amount of work was reported in published literature. Early investigation of this fiber property was accomplished in 1941 by Fox and Finzel (37) using a cylinder and piston device and a chain balance for loading and unloading (compression and decompression) the specimen under test. An improved method was reported by them (38) in which an Instron testing machine was used with a specially built cage for confining the fiber. This cage was described as a metal cylinder, six inches in diameter by four inches in depth, with a cover drilled to provide a two-inch hole through which a piston plunger, of two square inch end area, passed to compress the fiber. The use of a plunger of a smaller diameter than the inside of the cylinder was reported necessary to eliminate a negative force found when using a flat foot (plunger) the size of the sample under compression and to minimize the drag influence of a piston against the wall of a cylinder. They reported satisfactory reproduction of results in successive trials notwithstanding obvious variables inherent in arranging the fiber beneath the surface of the piston and within the cylinder. For these tests they used 50 gram samples and a variety of testing procedures. Compression with a 1000 gram maximum load followed by decompression and measurement of per cent compression was taken as one point of comparison. Compression was taken to be evidenced from travel of the piston from

start of loading to attainment of 1000 gram load. A more suitable measure reported by them was the difference in work put into compression, as measured by the use of an integrator device provided for use with the Instron, as compared to that recovered on decompression. Other tests were reported wherein test samples were subjected to a series of five cyclic tests of loading, followed by immediate unloading, with a comparison of the final total work put in as compared to the work derived from decompression of the sample. Another technique utilized was the so-called delayed recovery method wherein a sample was compressed then held for five minutes and allowed to recover. The measure used for comparison was per cent recovery of original dimension and the work loss between compression and decompression.

Another measure of the compression and recovery of textile fibers was reported in the technique of Busse (39) and Kolb, Busse and associates (40) in a cylinder and piston device utilizing high pressures of from 1500 to 100,000 pounds per square inch. Their appraisal consisted of examination of glazing of the surface of the compressed plug and in measurement of its recovery of original dimension (under a pressure of two pounds per square inch). A laboratory press was used to compress a one-gram sample of fiber inside the cylinder using a small diameter piston. Measurement of dimensional recovery was made 30 minutes

after removal of the compressed plug from the cylinder. Busse compared dyed cotton, undyed but scoured cotton, raw cotton, and absorbent cotton as to recovery from compression of varying pressures and observed 'hand'. Kolb and associates compared the compression recovery of certain synthetic fibers and rayon under extreme pressures as well as the 1500 pounds per square inch used by Busse on cotton.

Some compression studies on wool fiber were reported by de MaCarty and Dusenbury (41). In their studies an Instron Testing machine with compression cell was used to compress a pad of wool fiber of approximately 4 to 7 inches in diameter and some 3 inches in thickness between flat jaws. Considerable care was reported by them in combing out successive small pads of fiber to comprise the eventual test specimen. Several small pads of wool fiber combed out in a uniform manner were combined to form the test specimen. This care was taken to insure uniform arrangement of fibers in test specimens for a number of different test specimens.

As the primary objective in this research was to find a finish, a softener, which would enable commercially practicable processing of ramie fiber the basic experimentation was trial, by actual manufacturing test, of certain chemical preparations applied to different portions of a single degumming batch. These trials involved processing the staple fiber on conventional long staple fiber processing equipment similar to that used for processing synthetic

fibers. To afford a gauge of effect in a mechanical sense, certain instrumental tests aimed at comparing the influence of different softeners were selected. As a basic means of comparison, measurements of fiber friction and compaction were selected. In addition to these basic information tests other tests aimed at comparing the quality of product obtained in manufacturing trials were accomplished as a check on visual appraisal of performance characteristics of the differently treated lots of fiber.

After appraisal of equipment available for testing it was decided to accomplish tensile strength tests on card sliver using an Instron testing machine. This approach was expected to enable basic information tests to be accomplished on stock reasonably identical to that used in processing trials and to minimize the manipulative error inherent in individual fiber friction measurements.

For compaction measurements a compromise was found expedient in that pressures far in excess of the 1000 grams used by Fox and Finzel (34) were encountered in routine processing of fiber in drafting rolls and calender rolls. The extreme pressures used by Busse and associates (39, 40) appeared excessive in view of the marked compaction noted in routine processing equipment wherein pressures of less than 100 pounds were found. A compression cell for low pressures was not currently available, hence a compression cage was constructed for use with a conventional tension cell

used with the Instron for use of pressures of from 1 to 100 pounds. By use of this device the Instron could be used to accomplish tests in the range of pressure considered most significant for distinction of compaction characteristics.

CHAPTER III

EQUIPMENT AND INSTRUMENTATION

Equipment

Fiber processing equipment.--Conventional fiber processing equipment was used for opening, picking, carding, drawing, roving, and spinning as indicated in the tabulation below. Operating data of equipment employed was as indicated in Tables 3, 4, 5, 6, and 7 included in the Appendix. Specific machines used for manufacturing trials were as follows:

Whitin One-Process Picker

Saco Lowell Roller Top Card

Saco Lowell Revolving Flat Top Card

Medley Drawing Frame

Saco Lowell FS-1 Roving Frame

Saco Lowell Z Long Draft Spinning Frame

Fiber treatment equipment.--Standard laboratory beakers, enameled boiler, stirring rods, hand operated squeeze wringer and automatic temperature controlled air circulating oven were used for initial softening screening trials.

For bulk degumming and softening trials at Everglades Experiment Station the following equipment was used for fiber treatment:

Revolving steel pressure kier with provision for steam heating, liquor circulation, and a capacity for approximately 400 pounds of dry fiber.

Revolving steel pressure kier, single charge (no external circulation for treatment liquor), gas flame heat, capacity 13 pounds of dry fiber for softener application.

Improved opening equipment known as the SRRL equipped with specially designed beater blades and provision for air circulation for fiber blooming and minimum fiber breakage.

Procter and Schwartz card, a machine similar to a wool garnet card, equipped with a twenty-inch cylinder and a series of workers and strippers for separating small bunches of fiber into an open web which was bundled by hand for shipment and subsequent processing.

Testing Equipment -- Instrumentation

Fiber friction and compaction testing.--An Instron Tester was used for analysis of fiber friction as sliver drag. Uniform weight six inch samples of sliver were tested for breaking strength using a B tension cell with a load selector setting of 1000 grams maximum. An automatic record was obtained for the tests wherein the machine cross head speed was one inch per minute and the chart speed was five inches per minute. Flat faced, one inch square jaws furnished with the tension cell were used to clamp the sliver for test.

For fiber compaction tests a specially designed cage made of aluminum roll and sheet stock was constructed. This cage was designed in such a fashion that the upper assembly, attached to the load cell supported a four inch (inside diameter) cylinder, four inches in height. A cover was constructed of aluminum sheet and drilled to give ample clearance to a steel plunger attached to the lower assembly and fastened to the crosshead. The steel plunger, 1.5 inches in diameter (approximately two square inches in area), was thus used to compress the fiber as the crosshead travelled downward. Details of compaction tests are included in Chapter IV.

Product uniformity testing.--Routine tests as to product weight were made using standard length measures, conventional yarn and sliver reels and laboratory balances.

Product uniformity tests were made using the following:

Saco Lowell Sliver Tester

Uster Electronic Tester (Uniformity Tester)

Suter Single Strand Yarn Tester (Vertical, Oil Plunger Type)

CHAPTER IV

PROCEDURE

Initial Softener Screening

An initial screening of softener effect on degummed ramie fiber was accomplished by treating successive twenty-five gram lots of fiber taken from a single degumming batch. These small lots of fiber were treated in an aqueous dispersion containing two per cent of the several agents supplied by the manufacturers. Agents tested and their manufacturers are indicated in Table 1. The fiber was then removed, squeezed and dried without rinsing. The fiber was dried in a circulating oven at a temperature of 160°F for thirty-six hours. The dried fiber was then held in a standard test condition atmosphere (70°F and 65 per cent relative humidity) for 24 hours preparatory to carding on a Saco Lowell revolving flat top card. This card, equipped with metallic fillet clothing on workers and strippers, was used to open the pads of treated fiber for evaluation of 'hand'. The differently softened lots of fiber were compared by tactile evaluation to relate them as to relative softening by comparison with one another and with cotton and unsoftened fiber. A pad of fiber taken from the card without passing it through the card calender rolls was used for comparison.

Processing Quality Evaluation

Softening and opening.--From the initial screening a group of sixteen softeners were selected for bulk softening by personnel of Everglades Experiment Station, Belle Glade, Florida. Sample lots of approximately ten pounds each were taken from a single large degumming batch of some 300 pounds and treated with the softeners indicated in Table 2. Treatment was accomplished immediately following degumming and before drying the fiber therefrom. Each lot of wet degummed fiber was loaded into a small kier with a capacity of thirteen pounds of dry fiber and heated by means of a series of gas burners. Mechanical agitation of the fiber and treatment liquor was accomplished by rotation of the charged kier over the gas flames. The treatment liquor consisted of an aqueous dispersion of two per cent, except as noted, of the chemical agents indicated in Table 2. Two successive fifteen minute treatments at 180°F were accomplished using a fiber-liquor ratio of three to one. The fiber was then dried in an air circulating oven and opened by means of a SRRL opener and a Procter and Schwartz card.

Picking.--Sample lots of approximately five pounds each from these softened lots of fiber were forwarded to this investigator. Each lot was conditioned for 36 hours and processed on a Whitin One-Process Picker, using two passes through the machine to produce better uniformity, into laps for carding on a Saco Lowell Roller Top Card. In the first pass,

hand distribution on the feed apron was accomplished, and on the second, the laps were doubled on the feed apron.

Carding.--The short laps obtained from the picker were carded with appropriate adjustments in rate of feed to obtain card sliver of approximately 50 grains per yard. The variations inherent in picker processing of such small lots caused relatively wide variation in card sliver and necessitated frequent checks of sliver weight and change of feed roll gear to minimize such variation. Observations were made as to cohesion of fibers in the web, compacting tendency of fibers in the sliver and overall running quality. As an additional means of appraising processing quality, tests were made of the variation per foot of card sliver using a Saco Lowell Sliver Tester.

Samples of card sliver were withdrawn by selective weighings to obtain samples of sliver of approximately equivalent weight for Instron drag tests hereinafter described. Samples of carded fibers were withdrawn prior to passage through the trumpet and calender rolls for compaction tests described later.

Drawing trials.--Appropriate adjustments (see Table 5) were made on a Single Head Medley Four Roll Drawing Frame, equipped with fluted metallic rolls, to enable drafting the card sliver and parallelization of the fibers for roving manufacture. During the course of these trials necessary changes in the tension gearing were made as warranted by the

character of the softened fiber. Observations were made as to overall processing quality and tests were made as to variation per foot of drawing sliver using a Saco Lowell Sliver Tester.

Roving trials.--Two spindles were operated on a Saco Lowell FS-1 Long Draft Roving Frame to produce roving from the drawing sliver. Two ends of the drawing sliver from each lot of softened fiber were drafted using a uniform machine set-up (see Table 6) for all lots. Compensation for variation in the size of roving resulting from unavoidable variations in prior processing was accomplished by adjustment of the position of the cone drive belt in the drive to the bobbins. After a satisfactory adjustment of the cone belt position to give satisfactory cohesion of roving in spinning had been made, observations were made as to overall running quality. Tests were made to measure uniformity of the roving produced. A Uster tester was used to record, by electronic means, the variation in each yard of two ten-yard samples.

Spinning trials.--The roving produced as described above was used in limited trials to appraise spinning quality of the differently softened ramie fiber samples. A Saco Lowell Z type long draft spinning frame, which has a fixed roll setting except for the position of small, self-weighted control rolls, and utilizes a leather apron from back to a point near the bite of the front rolls, was adjusted (see

Table 7) to provide a draft ot ten then used for successive trials on each different lot of roving. Overall spinning quality was appraised by observation of the frequency with which piecings were required and the nature of and frequency of ends down. Overall processing quality apparent from two spindles operated negated the use of a more scientific ends-down test.

Instrumental Analysis

Instron sliver drag tests.--Samples of card sliver six inches in length were weighed and broken on an Instron Tester using one inch square flat faced jaws, a "B" tension cell with the load selector switch set for 1000 gram maximum load, and one inch per minute cross head speed. A graphic record was obtained using the automatic recorder set for a chart speed of five inches per minute. The automatic Integrator attachment was used to obtain the integral of the force times distance product of the record of the breaking strength test. The peak load, the work integral, and the weight of each sample was recorded for each of five successive tests on sliver from each differently softened lot of fiber.

Instron fiber compaction tests.--Samples of carded fiber taken directly from the doffer of the card (without calendering) were inserted in the four inch diameter sample receiver cylinder of the special compression cage described in Chapter III. The fiber was uniformly distributed in the cylinder by use of the fingers. For this series of tests on

a twenty five gram sample the following machine conditions were used:

Tension load cell	C
Load selector setting	20 pound
Cross-head speed	1 inch/minute
Chart speed	5 inch/minute
Cycling (extension) setting	3.0 inch cross head travel

Sample opened by machine carding
Two indications on the Integrator--compression and decompression cycles

The integrator attachment was utilized to measure the relative work done on the fiber on compression and also to measure the work recovered from decompression of the sample in each cycle for five successive cycles. Observations were made on each sample of the peak load on the initial cycle, the depression of the peak load after five cycles, the work loss on one cycle and the cumulative work loss after five cycles.

An additional series of tests were made utilizing the same conditions as listed above but on a fifty gram sample and cross-head cycling after 2.25 inches travel. The fiber for this series of tests was obtained from card sliver but was fluffed out by the use of a pair of hand cards. An additional series of tests was made utilizing a fifty gram sample and a load selector setting of fifty pounds maximum load and, again, hand card opened fiber.

Product uniformity tests.--Tests were made on the product from carding and drawing using a Saco Lowell Sliver Tester (42). These tests were accomplished as follows: The sliver under

test was inserted in the grooved roller of the machine and the lever arm adjusted so that the recorder pen registered about the index (0) line of the recorder chart, then the machine gap was determined from the coarse and fine adjustment scales. The recorder drive mechanism was set to provide three inches of chart motion for each yard of sliver. Determination of the variation was made as follows: The sum of the deviations of the high and low deviation of the recorder trace from the zero line in tenths of an inch for each foot of sliver divided by the width of the gap (in 0.001 inches) was determined; this sum of deviations divided by the number of feet of sliver included in the sum gave the variation in per cent. Tests were made on ten feet of sample from each lot of softened fiber and a sample of unsoftened fiber.

Tests on roving for uniformity were made using a Uster (Uniformity) Tester. This machine, which measures variations in the thickness of a sample of sliver or roving by electronic means (43), has become widely accepted in the textile industry for uniformity measurements on conventional fibers such as cotton and wool. Two ten yard samples of roving were tested and a graphic record of the electrical impulses transmitted to the recorder by the tester was made. The range of variation was calculated from the chart record by summation of the high and low values of deviation (in millimeters) from the mean value for each yard of roving,

application of a machine factor and dividing this result by the number of yards tested. The mean of two determinations for each sample lot was taken to be the range of variation in per cent per yard of roving.

Tests for uniformity of yarn were accomplished on each sample of yarn produced by means of single strand yarn breaking strength determinations. From these data the coefficient of variation for each sample lot of yarn was calculated. Division of the range of variation between the high and low tensile strength values from twenty determinations by a factor, 3.735, and dividing this result by the mean breaking strength, gave a valid coefficient of variation for a product of normal variation. The result, expressed as per cent, constituted a measure of the non-uniformity of the yarn produced and actually tested. The true variation was not thus accurately recorded in that breakage of the yarn at splices, etc., was not measured because such lengths were discarded.

CHAPTER V

RESULTS AND DISCUSSION

Initial softener screening.--Tactile evaluation enables selection of sixteen softeners from those listed in Table 1. The softeners selected for more extensive processing trials are listed in Table 2. As indicated in Table 1, certain of the samples tested were intermediates for the synthesis of surfactants, or softeners, and were eliminated on that basis. Combination of these ingredients with other compounds would, no doubt, enable formulation of a suitable softener but until a determination was made of the specific characteristics sought in a softener further trials were not warranted in this investigation. Appraisal of the 'hand' imparted to the bulk pads of fiber was extensively compared by the writer and by disinterested parties to select those pads of fiber which seemed to have a softer 'hand' than the unsoftened fiber and which most closely approximated the 'hand' of a pad of bulk cotton fiber.

Fiber processing trials.--Observations on fiber processing characteristics of the differently softened lots of fiber are indicated in Table 8. A numerical rating based on processing observations is indicated in Table 9.

A comparison of this nature based on a limited quantity of fiber and of necessity limited to small production quantities can be only indicative at best. Sufficiently large samples for ends-down tests and for stabilization of processing inequalities were not indicated by the comparatively poor processing quality, in general, of all the samples tested. Use of a larger sample appeared necessary to minimize the non-uniformity characteristic of picker processing of only a few pounds of fiber and thus to lend significance to uniformity testing of product at subsequent processing stages. An adequate comparison would require establishment of statistical validity using larger samples and a large number of determinations of sliver, roving and yarn uniformity from each sample lot. Since considerably more than five pounds of fiber are required for the picker processing conditions to be stabilized, a relatively uneven picker lap was the best obtainable. Such a lap permitted carding but the uniformity of card sliver naturally included sizeable long term variation. Doubling in drawing served to minimize the long term variation but adequate sizing for production trials in roving and yarn manufacture was impracticable.

These trials, however, served to indicate that application of an adequate amount of softener (of the proper composition) minimized the generation of static electricity and lessened the fiber's tendency toward compaction in the picking process. Similarly, lessened static and less evident

compaction was noted in carding and drawing on each of the softened lots. A relationship was evident between the hand of fiber and the processing character of the fiber in manufacturing trials. For example, the unsoftened fiber and those lots of fiber which exhibited a relatively harsh hand such as S-6 (Arko NI) and S-16 (SSS) were virtually impossible to process.

Determination of the best softener and the amount of softening required by the fiber was not readily apparent from a comparison of the softeners tested by yarn manufacture processing.

It was evident that use of a cationic softener was more suitable from the standpoint of the concentration required in the application bath as appraised by tactile evaluation of card sliver (Tables 2 and 9). A concentration of one half per cent, by volume of bath, afforded approximately equivalent 'hand' to other softeners applied from a two per cent bath.

The processing quality of S-15 (Avitex MLF) was poor but the 'hand' of the sliver was comparatively soft. Its poor processing quality appeared to stem from poor cohesion in roving form.

Since anionic and non-ionic softeners depend upon physical deposition on the fiber as distinguished from an affinity for cellulosic fibers exhibited by the cationic type of softener the cationic type afforded more assurance of optimum softening.

Tactile evaluation of softened fiber after carding afforded an indication of its processing potential but did not indicate whether excess deposition of softener had caused over-lubrication. For example, S-8 (Nopcotex B) appeared to be approximately equal in 'hand' to S-1, S-2, and S-4 (Soromine AT, AL, BSS, respectively) but in processing tended to adhere to the rolls of roving and spinning frames. The subtle difference in fiber friction which apparently distinguished fair performance from good was not apparent from tactile evaluation. Sliver drag tests enabled a measure of such influence.

No explanation was found for the difference in performance of S-17 and S-18 which were, purportedly, given identical treatment in softening (two per cent Avitex C). It is a speculation that, since instrumental analysis of fiber friction (see sliver drag tests) indicated marked frictional differences, the manufacturing processing difference could be attributed to experimental error in softening.

Instrumental analysis.--Results of Instron sliver drag tests are recorded in Table 9. Results of tests for product uniformity at the different stages of manufacture are tabulated in Tables 10, 11, and 12.

Fiber compaction test data were discarded due to difficulties encountered in obtaining reproducible results. The use of the compression loads of twenty and fifty pounds

instead of the 1000 grams used by Fox and Finzel (38) or the high pressures used by Busse (39, 40) was selected in anticipation of instrumental distinction of such characteristic under test conditions more nearly approximating those encountered in actual processing on staple fiber equipment. This choice of method proved to be unsatisfactory but the reason for failure to obtain reproduction of results in successive trials was not readily apparent. Magnification of the error inherent in the physical placement of the samples in the cylinder of the compression cage may have been the reason for this investigator's failure to confirm the reproduction of test results reported by Fox and Finzel. By the same token, the extreme pressures used by Busse may have satisfactorily masked this variable. The characteristic tendency of the fiber to compact seemed to be the major influence in the failure to obtain reproduction of test results. Since tests to confirm the original findings were accomplished on hand-card opened fiber which had been calendered in picking and in carding the compaction had already been accomplished prior to the Instron compaction tests.

Instrumentation.--Product uniformity tests performed to verify the observations made of processing quality were inconclusive. The roving and yarn subjected to test were that which had been produced regardless of the number of piecings involved in the process. The low variations noted

in card and drawing sliver as measured on a Saco Lowell Sliver Tester were, in general, in line with commonly accepted standards for even cotton sliver (42) and did not reflect the short term variation apparent in Uster Uniformity trials on the roving produced therefrom. These Uster range of variation values for ramie roving (See Table 11) were greatly in excess of those tabulated by the developers of the testing machine as typical of uneven cotton roving (43, p. 7) (very uneven = 23, uneven = 45). A significant observation was made in Uster roving tests that a very marked short term variation was recorded on the graphic record of tests (See Figure 1). The size of the individual ramie fibers, found by microscopic examination to range from 10 to 70 microns in diameter, was believed to account in a large measure for the wide fluctuations of the recorder trace. The spacing of individual fiber ends in the roving due to a wide range of staple lengths known to exist in the fiber which was processed was also believed to be a causative factor. Each of these factors would be expected to cause fluctuation in the electronic measure of the thickness of the roving as well as to account, in part, for the poor processing quality found in roving and yarn spinning.

Studies to confirm this impression as to fiber size and staple length and their probable influence on processing quality and uniformity test records were considered to be

beyond the scope of this investigation. The fact that the fiber ribbons were stapled to a 2-1/2 inch length prior to degumming but in draw frame processing the mean length was less than 1-3/4 inches led to the conclusion that a considerable amount of fiber breakage occurred in processing prior to drawing. That such breakage would cause a considerable number of short fibers appears logical. This was further confirmed by observations of considerable short fiber fly at all stages of processing. Touloukian (44) reported fiber breakage in yarn manufacture on cotton processing equipment. A decrease of such occurrence was expected as a result of the fiber softening accomplished in these trials but no detailed study of this aspect was undertaken because of the limited quantity of fiber available. Such a detailed analysis would require relatively large samples of fiber to permit a valid sampling technique at each stage of fiber processing to afford significant data on fiber breakage.

Summary.--The basically poor fiber processing qualities made appraisal of softener influence on the fiber samples tested difficult. The fact that application of any of the softeners tested enhanced the picking and carding processing characteristics of the degummed ramie used in these trials appears to be conclusive evidence of the necessity of softening the fiber. Distinction of the most suitable softener was hampered by the inability of obtaining clearly

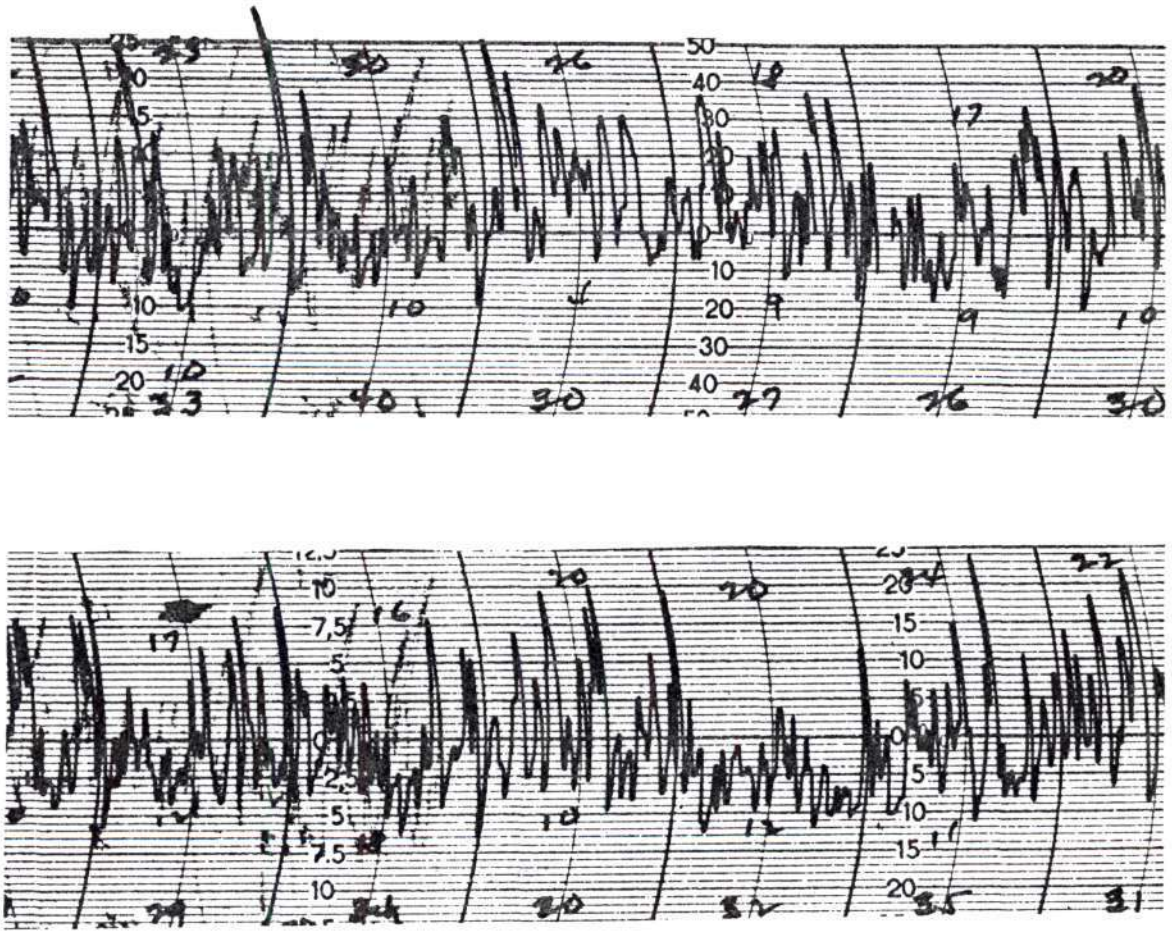

Figure 1. Ramie - Uster Roving Recorder Chart
1 inch of chart = 1 yard of roving

significant difference in processing because of the very low level of performance observed in all the lots of fiber. While significant differences of a reproducible nature were obtained through the use of sliver drag measurements, determination of the true significance of these differences as regards the ultimate goal (commercially practicable yarn manufacture) was not feasible. Indications are that if the processing quality was sufficiently enhanced by softening, optimum sliver drag could be determined on the basis of yarn quality and uniformity tests. Such data, in turn, could be used for determination of the most suitable chemical softener and its concentration. While such a measure was indicated by these studies, determination of this optimum value was not established because of acknowledged shortcomings in the uniformity of both the product and the sampling techniques used.

CHAPTER VI

CONCLUSIONS

Limitations imposed by the relatively poor processing quality of ramie fiber tested, whether softened or not, made it difficult to draw valid conclusions regarding the effect of different softeners on processing quality.

It was readily apparent, however, that:

1. The use of any one of a variety of chemical softeners aids the processing of stapled ramie fiber, particularly in picking and carding. In overall appraisal of processing quality the cationic type agents rendered the greatest improvement. Types AT and BSS Soromines were the most outstanding in softening effect and processing improvement.

2. Undoubtedly a relationship exists between fiber friction as measured in card sliver drag on an Instron Tester and processing quality of the fiber. Numerous chemical agents advantageously influence this fiber friction.

3. Insufficient distinction was afforded by these studies to ascertain a range of sliver drag values which would enable a prediction of optimum processing quality based on such instrumental data.

4. Factors other than extent of softening or lubricity of fiber appeared to be of equivalent or greater influence in the processing of stapled ramie fiber having similar origin and degumming treatment to that employed in these trials.

5. Fiber compaction measurements accomplished by the techniques employed in this investigation were inconclusive for the ramie fiber used in these tests.

6. In order to establish statistical validity in experimental observations and to minimize machine-characteristic processing deficiencies which affect product uniformity appraisal, larger fiber samples appear necessary. Additionally, a processing level of higher quality than that obtained in these studies appeared necessary for worthwhile comparison of softener effect.

CHAPTER VII

RECOMMENDATIONS

It is recommended that further studies be accomplished to ascertain those measures necessary to obtain a level of quality which may enable the economic processing of ramie staple fiber into yarns and fabrics. Toward this end the following appear worthy of investigation:

1. Determination of optimum ramie fiber attributes which are commercially attainable. These might include such factors as: staple length distribution; fiber diameter; fiber quality; degree of separation to individual fibers; and, degumming procedure for maximum retention of desirable fiber qualities.

2. Further analysis of the preparation and characteristics of degummed ramie fiber to determine those properties responsible for its recognized inferior processing characteristics and the development of chemical and/or physical treatments to overcome these characteristics. Specific properties recommended for investigation are its tendency to compaction and adhesion and its imperfections in construction and configuration.

3. Further studies in connection with instrumental measurement of sliver drag, fiber compaction, and

other characteristics found worthy of investigation; Comparison with other fibers in a limited number of bulk processing studies so that a basis might be obtained for the prediction of processing potential of small treated lots of fiber on instrumental test data.

4. Studies in connection with the use of other staple fibers in blends with ramie fibers to utilize desirable attributes of each fiber and to overcome basic processing obstacles encountered in the processing of staple ramie fiber.

APPENDIX

Table 1

MANUFACTURERS AND SOFTENING-ANTISTATIC AGENTS

Manufacturer and Product	Ionic Nature	Generalized Chemical Nature*
Arkansas Company, Inc., P. O. Box 210, Newark, New Jersey		
Arkolube LS	nonionic	high molecular weight fatty ester
Arkolube SIL	nonionic	silicone emulsion
Arko Finish GP	cationic	combination of amino-fatty condensation products and synthetic fatty esters
Arko Finish NI	nonionic	synthetic fatty esters and hygroscopic agents
Paramel GT	anionic	amino fatty condensation product plus emulsifying agents
Paramine TA	cationic	amino-fatty condensation product
Archer Daniels Midland Co., Chemical Products Division, 2191 West 110th St., Cleveland 2, Ohio		
Hydrofol Acids 420	- - -	intermediate compound for synthesis of surfactant-softener
Hydrofol Glycerides, T-57-N Flakes	- - -	intermediate for synthesis of softener
Cosmol 1000	- - -	intermediate for synthesis of softener
Adol 65 plus 10 moles ethylene oxide	- - -	intermediate (cetyl and stearyl alcohols)
Adol 34	- - -	intermediate (fatty alcohols)

(Continued)

Table 1 (Continued)

MANUFACTURERS AND SOFTENING-ANTISTATIC AGENTS

Manufacturer and Product	Ionic Nature	Generalized Chemical Nature+
Arnold, Hoffman and Co., Inc., 55 Canal Street, Providence 1, Rhode Island		
Ahcohein 810	- - -	intermediate for synthesis of softener (oleic acid)
Butyl stearate	- - -	lubricant, plasticizer (butyl stearate) (use with other agent)
Celax	nonionic	emulsifiers and mineral oil
Synthraven SL	anionic	blend of highly sulfonated fats
Scrooping agent D	nonionic	fatty acid - ethylene oxide condensate
Ahcovel A	cationic	fatty carbamide salts
Ahcovel G	cationic	fatty carbamides
Ahcovel R	anionic	fatty carbamide salts
Ahcovel 346	anionic	fatty carbamide salts
Ahcovel X-57	cationic	not given
American Cyanamid Co., Organic Chemicals Division, 30 Rockefeller Plaza, New York, New York		
Aerotex Softener H	ampholytic*	mixed cationic and anionic long chain derivative
No-Odorol 12998	anionic	stabilized, sulfated oils
Cyanatex 515	anionic	sulfonated animal fats
Cyanatex 517	anionic	sulfonated animal fats

(Continued)

Table 1 (Continued)

MANUFACTURERS AND SOFTENING-ANTISTATIC AGENTS

Manufacturer and Product	Ionic Nature	Generalized Chemical Nature†
Cyanatex 3082	nonionic	neutral nonionic emulsion of waxes
Cyanatex 3119	nonionic	not given
Cyanatex 3130	not given believed non-ionic	not given
Cyanatex OAE	not given believed cationic	reaction product fatty amine and oxyalkane
American Viscose Corporation, 1617 Pennsylvania Blvd., Philadelphia, Pennsylvania		
Avcodisk	- - -	for use in softening yarns at spinning and twisting (cake form)
Apex Chemical Co., Inc., 200 South First St., Elizabethport 1, New Jersey		
Apexomide 735	ampholytic*	not given
Velvawax #6	not given believed non-ionic	not given
Metro-Atlantic, Inc., 2072 Smith St., Centredale 11, Rhode Island (Atco)		
Atcotal S (75%)	not given	75-per-cent sulfonated tallow
Atco Wax JN	not given believed non-ionic	solubilized wax-stearate combination
Atcosoft N	ampholytic*	amine condensate
Atcosoft SD	cationic	fatty acid amine condensate

(Continued)

Table 1 (Continued)

MANUFACTURERS AND SOFTENING ANTISTATIC AGENTS

Manufacturer and Product	Ionic Nature	Generalized Chemical Nature[+]
Atcozyme H Sol.	- - -	for use in degumming studies in conjunction with softener
D-Stat X-30	anionic	fatty acid amine condensate (antistatic agent)
Charles W. Berg Laboratories, 1827 N. Fifth St., Philadelphia, Pennsylvania		
Compound 6604	- - -	volatile oils, antistatic agent, emulsifier
Biddal 4922	not given	fatty amide with nonionic fatty derivative
Berkshire Color and Chemical Corporation, Springfield, Massachusett		
Berapon CS-30	cationic	complex amido derivative
Berapon S-40	nonionic	fatty acid alkanolamine condensate; precipitates with 600-ppm hard water
Berapon S-50	anionic	highly sulfated tallow
Berapon S-60	ampholytic*	fatty amido compound
Berapon LD 102	not given	not given - reports high temperature resistance
Catalin Corporation of America, New York, New York		
Discontinued manufacture of textile softeners		
Chas. S. Tanner Co., 250 South Water St., Providence 3, Rhode Island		
Lubritone	anionic	fatty ester
Synolube C	cationic	fatty amine

(Continued)

Table 1 (Continued)

MANUFACTURERS AND SOFTENING-ANTISTATIC AGENTS

Manufacturer and Product	Ionic Nature	Generalized Chemical Nature[4]
The Dow Chemical Company, Midland, Michigan		
Four preparations, polyglycols and oxypropylene substitute compounds for use in formulation of softener		
Dexter Chemical Corp., 819 Edgewater Road, New York 59, New York		
Ampitol J-177	not given	not given
Lektrostat B	anionic	not given
Lektrostat C	cationic	not given
E. I. DuPont de Nemours and Co., Inc., Wilmington 98, Delaware		
Avitex C	anionic	long chain alcohol sulfate
Avitex R	cationic	high alkylamine
Avitex NA	cationic	higher alkylamine
Spinning Lubricant L	not given believed anionic	alcohol sulfate
General Aniline and Film Corp., Antara Chemicals, 2459 Wilkinson Blvd., Charlotte, North Carolina		
Soromine AL	ampholytic*	complex fatty amide amphoteric compound
Soromine BSA	cationic	derivative of higher alkylamines
Soromine AT	ampholytic*	complex fatty amide compound
Soromine BSS	cationic	derivative of higher alkylamines
Soromine BNS	cationic	derivative of higher alkylamines
Soromine CS	cationic	fatty amino amide compound

(Continued)

Table 1 (Continued)

MANUFACTURERS AND SOFTENING-ANTISTATIC AGENTS

Manufacturer and Product	Ionic Nature	Generalized Chemical Nature+
Soromine FW	anionic	sodium salt of a fatty amide complex
Emulphor EL 719	nonionic	polyethylene ester of fatty acid
Katapol PN-430	nonionic	alkyl polyoxyethylene amine
Monopol Oil 48	anionic	sulfated castor oil
W. H. and F. Jordan, Jr. Mfg. Co., 3047 Amber St., Philadelphia, Pennsylvania		
Borne Scrymser Co., 632 South Front St., Elizabeth New Jersey		
Carbide and Carbon Chemicals Co., Union Carbide and Carbon Corp., 30 E. 42nd St., New York 17, New York		
No response		
Onyx Oil and Chemical Co., Warren and Morris Sts., Jersey City 2, New Jersey		
Ammonyx BC	cationic	trialkylbenzylammonium chloride
Aston R	not given believed cationic	not given - intended as anti-static agent
Mollisan	nonionic	not given - intended as softener, lubricant
Nopco Chemical Co., First and Essex Sts., Harrison, New Jersey		
	Not Given believed to be:	
Boerite	anionic	sulfated fatty acid
Nopco 100	nonionic	soluble fatty ester
Nopco 1556	nonionic	solubilized blend of fractionated oils

(Continued)

Table 1 (Concluded)

MANUFACTURERS AND SOFTENING-ANTISTATIC AGENTS

Manufacturer and Product	Ionic Nature	Generalized Chemical Nature+
Nopco 1921-D	nonionic	solubilized blend of fractionated oils
Nopco 2152-P	nonionic	fatty ester
Nopco AS-40	cationic	fatty amide
Nopcotex B	nonionic	hydroxylated ester
Nopcotex H	cationic	fatty amide
Nopcov	nonionic	highly sulfated oleoglyceride
Quaker Chemical Products Corp., Conshohocken, Pennsylvania		
Velvetol AF	cationic	amino fatty condensation products
Velvetol SS	nonionic	dispersible fatty esters
L. Sonneborn and Sons, Inc., 300 Fourth Ave., New York 10, New Yor		
Fybrol 1000	nonionic	fatty oils, nonoxidizing hydrocarbons with static inhibitor
Fybrol 2531	nonionic	nonionic emulsifiable oil
Wyandotte Chemicals Corp., Wyandotte, Michigan		
Pluronics L-44, L-61, L-62,L-64, F-68	nonionic	surfactants based on ethylene and propylene oxides

+ As listed in the 1956 Yearbook of the American Association of Textile Chemists and Colorists and/or manufacturers' brochures.

* Cationic in acid medium, anionic in alkaline medium.

Table 2

SOFTENERS FOR PROCESSING COMPARISON

Sample Number	Softener Applied	Concentration Based on Volume of Bath %	Ionic Nature
S-1	Soromine AT	2	Cationic-Anionic[b]
S-2	Soromine AL	2	Cationic-Anionic[b]
S-3	Soromine BNS	2	Cationic
S-4	Soromine BSS	2	Cationic
S-5	Arko GP	2	Cationic
S-6	Arko NI	2	Nonionic
S-7	Paramine TA	2	Cationic
S-8	Nopcotex B	2	Not given-believed nonionic
S-9	Nopcotex H	2	Not given-believed cationic
S-10	Nopcov	2	Not given-believed nonionic
S-11	AtcoWax JN	2	Not given-believed nonionic
S-12	Velvetol AF	2	Cationic
S-13	Avitex R	2	Cationic
S-14	Avitex ML	1/2	Cationic
S-15	Avitex MLF	1/2	Cationic
S-16	Masury-Young's SSS[a]	2	Anionic
S-17	Avitex C[a]	2	Anionic
S-18	Avitex C[a]	2	Anionic

[a] Samples tested to provide a basis for comparison. Initial screening indicated fiber softened with these agents was harsh.

[b] Ampholytic - cationic in acidic meadium, anionic in alkaline medium.

Table 3

OPENING AND PICKING OPERATING DATA

Opening Equipment

Southern Regional Research Laboratories Opening and Blending Equipment (Operated by Everglades Experiment Station)

Procter and Schwartz Breaker Card -- 20 inch Width (Operated by Everglades Experiment Station)

Picking Equipment

Whitin One-Process Picker

Width of Machine (Inches)	38
Diameter of Feed Roll (inches)	2-1/2
RPM of Feed Roll	7
Type Beater	Modified Kirschner (for synthetic staple fiber)
RPM of Beater	780
Diameter of Beater	18
RPM of Fan	1230
RPM of Screen Section	1-1/2
Diameter of Calender Roll (inches)	5-1/2
RPM of Calender Roll	7
Draft Constant	0.125
Draft of Machine	2.5
Draft Gear	20

Operating Conditions - Picking

Stock	Ramie 2-1/2 Inch Staple
Temperature of Room (^{o}F)	80
Relative Humidity (per cent)	55
Pounds per Lap (each sample)	5

Table 4

CARDING OPERATING DATA

Equipment

Saco Lowell Roller Top Card (1948)

Width of Machine (inches)	40
Diameter of Licker-In Pulley	8
RPM of Licker-In	372
RPM of Cylinder	165
RPM of Doffer	7.25
RPM of Strippers	10
RPM of Workers	270
Draft Constant	1525
Draft Gear	13-17) varied within
Draft	----) each lot
Production Gear	20

Card settings (inches)

Doffer to Cylinder	0.007
Licker-In to Cylinder	0.007
Screen to Cylinder, back	0.022
Screen to Cylinder, bottom	0.058
Screen to Cylinder, front	0.187
Feed Plate to Licker-In	0.012
Workers to Cylinder	0.010
Strippers to Workers	0.010
Strippers to Cylinder	0.010

Operating Conditions

Temperature of Room (^{o}F)	80
Relative Humidity (per cent)	61
Lap Fed (oz/yard)	16 (variable)

Table 5

DRAWING OPERATING DATA

Equipment

Medley Single Head Drawing Frame (Five Roll Type, Four Rolls Used) Medley Manufacturing Company (1945)

Type of Top Rolls	Metallic
Diameter of Bottom Rolls (inches)	
Front:	1-3/8
Back:	1-1/2
Diameter of Calender Roll (inches)	2
Draft Gearing:	

$$\frac{60 \times 110 \times 33 \times 60 \times 2''}{(1) \times 24 \times 68 \times 30 \times 1.5'' \times 1.47 \text{ (fluting allowance)}} = 242$$

Draft Constant	242
Draft	6.2
Draft Gear	39
Roll Settings: (inches)	
Front to Second	2
Second to Third	1-3/4
Third to Back	1-3/4

Operating Conditions

Temperature (^{o}F)	80
Relative Humidity (per cent)	61
Sliver Fed (grains/yd) (approximate mean)	60

Table 6

ROVING OPERATING DATA

Equipment

Saco Lowell Long Draft Roving Frame (1948)

Package size	10 x 5
Spindles operated	2
Type of top rolls	Synthetic covered
Diameter of front roll	1-1/8
Draft gearing:	

$$\frac{35 \times 82 \times 60 \times 88 \times 1\text{-}1/8}{48 \times 24 \times (1) \times 18 \times 1\text{-}1/8} = 499 \text{ Constant}$$

Twist Gearing:

$$\frac{40 \times 51 \times 46 \times 60 \times 39 \times 18 \times 44}{40 \times 51 \times 46 \times 33 \times (1) \times 15 \times 23 \times 1\text{-}1/8 \times 11} =$$

Twist Constant	46
Twist Gear	29
Tension Constant	60
Tension Gear	62
Lay Constant	43
Lay Gear	28
Roll settings (inches)	
Front to Middle	3-1/16
Middle to Back	2-3/16

Operating Conditions

Temperature of room (^{o}F)	78
Relative humidity-per cent	56
Sliver fed (grains/yd)	(uneven-due to initial picking variation) mean = 50

Table 7

SPINNING OPERATING DATA

Equipment

Saco Lowell Z Long Draft Spinning

Spindles operated	2
Diameter of cylinder (inches)	8
Diameter of whorl (inches	1-1/8 (plus 1/16" tape)
Diameter of front roll (inch)	1
Diameter of back roll (inches)	7/8
Type of top roll covering	Leather
Type of drive	Tape
Type of spindle	McMullan

Draft gearing:

$$\frac{104 \times 129 \times 1"}{(1) \times 24 \times 7/8"} = 569 \text{ Draft Constant}$$

Twist gearing:

$$\frac{95 \times 149 \times 8"}{(1) \times 45 \times (1\text{-}1/8 + 1/16) \times 3.1416 \times 1"} = 675$$

Twist multiplier	4.50
Draft gear	67
Twist gear	54

Operating Conditions

Temperature of room (^{o}F)	75
Relative humidity (per cent)	60
Size of roving fed (range)	160-233 HR
Yarn counts (range)	6-10

Table 8

FIBER PROCESSING CHARACTERISTICS SUMMARY

Sample Number	Characteristics
	PICKING AND CARDING
L-1, S-1 Thru S-18	Except for L-1 (unsoftened fiber) no apparent differences were noted in the picking and carding processes. The unsoftened fiber in L-1 was severely compacted by the calender rolls of the picker and in carding poor cohesion in the web was noted, considerable fly and severe compaction of the sliver by the card calender rolls. The softened samples exhibited fair cohesion in the web, some fly and marked, though less than the unsoftened, compaction of the sliver in carding.
	DRAWING, ROVING AND SPINNING
S-1	Drawing quality--satisfactory, sliver had soft hand (rank 3), web even in appearance, required normal tension. Roving processing quality--fair, required negligible attention. Spinning quality--excellent, no ends down from start.
S-2	Drawing quality--satisfactory, even web, normal tension, sliver had soft hand (rank 3). Roving processing quality--fair, required negligible attention. Spinning quality--good, few ends down.
S-3	Drawing quality--satisfactory, even web, normal tension, sliver had soft hand (rank 4). Roving processing quality--fair, required negligible attention. Spinning quality--good, few ends down.
S-4	Drawing quality--fair, required increased tension between front roll and calender rolls to prevent bellying down, sliver had soft hand (rank 3). Roving processing quality--fair, required negligible attention. Spinning quality--excellent, no ends down from start.

(Continued)

Table 8 (Continued)

FIBER PROCESSING CHARACTERISTICS SUMMARY

Sample Number	Characteristics
S-5	Drawing quality--fair, even web, normal tension, sliver had harsh hand (rank 2), compacted severely. Roving processing quality--poor, required frequent attention. Spinning quality--poor, barely practicable.
S-6	Drawing quality--poor, very harsh, compacted sliver (rank 1), web even, normal tension. Roving processing quality--poor, virtually impractical. Spinning quality--not practicable.
S-7	Drawing quality--good, web even, normal tension, soft hand (rank 5), comparatively lofty sliver. Roving processing quality--excellent. Spinning quality--fair.
S-8	Drawing quality--fair, soft hand (rank 3), somewhat compacted sliver, web even, normal tension. Roving processing quality--fair, fibers exhibited tendency to adhere to rolls. Spinning quality--poor, flaky drafting apparent.
S-9	Drawing quality--satisfactory, sliver softened (rank 5) but somewhat compacted. Roving processing quality--poor, poor cohesion in roving (somewhat lighter than other stock processed). Spinning quality--fair.
S-10	Drawing quality--satisfactory, sliver somewhat softened (rank 3) but compacted, web even, tension normal. Roving processing quality--fair. Spinning quality--fair.
S-11	Drawing quality--satisfactory in running, soft hand (rank 4), slightly compacted sliver, web even, normal tension. Roving processing quality--fair. Spinning quality--fair.

(Continued)

Table 8 (Continued)

FIBER PROCESSING CHARACTERISTICS SUMMARY

Sample Number	Characteristics
S-12	Drawing quality--fair, sliver somewhat softened (rank 4), slightly compacted, web even, normal tension. Roving processing quality--fair. Spinning quality--fair.
S-13	Drawing quality--fair, soft hand (rank 3), slightly compacted sliver, web even, normal tension. Roving processing quality--fair. Spinning quality--poor, numerous ends down.
S-14	Drawing quality--fair, sliver somewhat softened (rank 3), compacted, web even, normal tension. Roving processing quality--fair. Spinning quality--fair.
S-15	Drawing quality--fair to poor, sliver somewhat softened (rank 3), slightly compacted, web uneven, required tension increase between front roll and calender roll, intermediate tension adequate to prevent end breakout unattainable. Roving processing quality--poor, drawing sliver unsuitable. Spinning quality--not run.
S-16	Drawing quality--poor, harsh, unduly compacted sliver (rank 1), web uneven, normal tension, trials discontinued due unsuitability. Roving processing quality--not run. Spinning quality--not run.
S-17	Drawing quality--fair, softened (rank 3) but compacted sliver, web even, normal tension. Roving processing quality--fair. Spinning quality--fair.

(Continued)

Table 8 (Concluded)

FIBER PROCESSING CHARACTERISTICS SUMMARY

Sample Number	Characteristics
S-18	Drawing quality--poor, softened (rank 4), slightly compacted sliver, web uneven, required tension increase but tended to break out ends. Roving processing quality--poor, cohesion in roving unsuitable. Spinning quality--impractical due to poor cohesion of roving in creel.
L-1	Original unsoftened fiber draftable on standard drawing setting but very harsh, unduly compacted sliver resulted, roving manufacture impractical.

Note: Ranking of 'hand' obtained by comparison of different samples and cotton fiber pads of similar size, etc., Cotton - rank 6, more harsh than cotton but considerably softened - rank 5, softer than original fiber but still harsh - ranks 4, 3, 2, very harsh likened to original fiber - rank 1. Card sliver used for appraisal.

Table 9

INSTRON SLIVER DRAG vs. PROCESSING QUALITY

Sample Identification Number	Sample Mean Weight (grains)	Drag Mean Peak (grains)	Peak Load Drag Factor[a] (peak/wt.) (x 10)	Drag Mean (gm-in)	Work Integral Drag Work Factor[b] (gm-in/gr) (x 10)	Process Quality Points[c]	Hand[d]
S-1	8.4	145	173	469	559	4 2 3	3
S-2	8.4	125	149	419	498	3 2 3	3
S-3	8.5	137	162	467	549	3 2 2	4
S-4	9.4	179	190	556	591	4 2 2	3
S-5	8.2	134	164	439	533	1 1 2	2
S-6	8.4	297	354	918	1090	0 1 1	1
S-7	9.6	153	159	467	486	2 4 3	5
S-8	9.3	166	179	694	746	1 2 2	3
S-9	8.9	157	177	546	612	2 1 3	5
S-10	8.5	154	181	460	542	2 2 2	3
S-11	8.7	132	154	432	496	2 2 3	4
S-12	9.4	135	143	425	452	2 2 2	4
S-13	9.4	131	140	391	416	1 2 2	3
S-14	8.6	145	169	519	602	2 2 2	3
S-15	9.7	185	191	585	602	0 1 1	3
S-16	7.5	168	224	625	833	0 0 1	1
S-17	8.5	142	167	481	565	2 2 2	3
S-18	9.8	141	144	389	397	0 1 1	4
Unsoft-	9.7	604	620	1288	1322	0 0 1	1
Cotton	8.6	120	140	714	830	5 4 4	6

[a] Drag factor computed by dividing mean drag peak value by weight of sample of sliver (in grains).

[b] Drag work factor computed by dividing mean drag work integral by weight of sliver sample (in grains).

[c] Process quality points assigned on basis of observations in manufacturing trials, first digit denotes spinning quality, second digit denotes roving quality, third digit denotes processing quality. Quality points assigned on following basis: 0-impractical, 1-poor, 2-fair, 3-good, 4-excellent, 5-superior.

[d] Hand appraisal as indicated in Table 8.

Table 10

SLIVER UNIFORMITY

Sample Number	Card Sliver Variation/foot Gap (0.001 inch)	Maximum (%)	Mean (%)	Weight[+] (gr/yd)	Drawing Sliver Variation/foot Gap (0.001 inch)	Maximum (%)	Mean (%)	Weight[+] (gr/yd)
S-1	50	9.1	8.4	67	40	30.0	18.6	60
S-2	55	9.1	4.9	71	35	34.2	22.5	52
S-3	60	8.3	3.9	88	40	35.0	20.9	59
S-4	50	8.0	6.5	62	25	34.0	28.0	42
S-5	45	12.2	9.2	62	40	38.8	26.2	58
S-6	65	6.2	3.7	80	45	33.3	21.9	66.5
S-7	45	10.0	7.8	61	40	27.5	20.7	51
S-8	35	14.2	7.7	59	30	43.3	28.2	50.5
S-9	20	22.5	17.0	33	35	28.5	22.7	53
S-10	35	11.2	10.1	53	40	27.5	18.2	58
S-11	35	22.9	13.6	57	20	55.0	39.0	28
S-12	45	22.0	15.8	59	25	38.0	26.8	42
S-13	30	16.6	13.5	42	25	40.0	33.0	42
S-14	40	18.7	11.1	53	35	27.2	18.7	52.5
S-15	50	14.0	9.3	69	40	31.3	22.7	58
S-16	30	55.0	25.3	44	30	21.6	16.3	50
S-17	40	12.5	8.0	52	40	40.0	22.5	55
S-18	45	15.5	9.3	63	40	72.0	29.5	57
Unsoft.	55	12.7	8.2	73	50	34.0	21.8	70

[+] Weight per yard indicated was found not truly representative of actual weight throughout due to variations in weight of picker lap, basic in process.

Table 11

ROVING UNIFORMITY

Sample Number	Hank Roving	Percent Variation (Uster)
1	1.62	135.4
2	1.72	134.4
3	1.96	113.8
4	1.81	125.0
5	1.64	153.1
6	Flaky drafting made roving manufacture impracticable	
7	1.68	130.8
8	1.82	138.8
9	2.33	133.6
10	1.65	148.2
11	1.59	105.0
12	1.67	126.8
13	1.96	125.2
14	1.86	118.4
15	Drawing impractical	
16	Roving manufacture impractical	
17	1.73	135.5
18	1.79	150.6

Table 12

YARN BREAKING STRENGTH - VARIATION

Sample Number	Mean Breaking Strength lbs.	Break Factor (counts x strength)	Coefficient of Variation# %	Mean Elongation %	Yarn Counts*
1	2.24	14.90	5.9	5.10	6.67
2	2.26	15.20	8.2	5.10	6.70
3	2.14	17.40	10.9	4.45	8.30
4	2.15	15.80	6.9	5.00	7.33
5	1.69	14.10	24.6	4.25	8.33
6	Yarn manufacture impractical				
7	2.22	15.40	7.5	4.65	7.00
8	Yarn manufacture impractical				
9	1.91	19.10	18.4	3.61	10.00
10	2.39	16.10	4.2	4.30	6.75
11	2.53	16.40	5.9	5.00	6.50
12	2.39	15.25	4.9	4.63	6.40
13	1.50	12.00	18.0	4.70	8.10
14	1.35	10.80	10.0	4.18	7.85
15	Yarn manufacture impractical - Drawing impractical				
16	Yarn manufacture impractical - Roving impractical				
17	1.78	11.85	22.4	3.20	6.67
18	Yarn manufacture impractical - poor cohesion of roving				

Coefficient of variation computed by dividing range of tensile strength values from twenty tests by 3.735, then dividing result by means of individual breaking strengths pursuant to suggestion by Wesson (45).

* Yarn counts computed from single determination of weight of 120 yards of yarn as insufficient yarn was spun to permit more tests.

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